Colorado.—March was not so stormy as usual over the greater part of the mountain region, and, taken as a whole, the precipitation was below normal, although local excesses were noted in nearly every watershed. Considerable snow has melted in the valleys, and a large proportion of the moisture is being absorbed by the dry soil. Above 9000 feet the depths are practically the same as a month ago, the current fall generally making good the loss in depth by the gradual settling of the old snow, much of which is in a condition to remain late in the season. The outlook for a good and prolonged flow is unusually favorable for the Rio Grande; on other watersheds the early flow promises to be much better than last year's, but the late flow will be less than normal if not augmented by rainfall.

Idaho.—At the close of March the measurements showed that the amounts on the ground were in excess of the average in nearly all sections. With a few localities excepted, an abundance of water for irrigation is assured.

Montana.—On March 31 the prospects for a good flow of water, which, from present indications, will last until late in the season, were very favorable throughout the greater portion of the State. There are some localities in which the snowfall has been below the average, or in which the snow is not drifted or firm, and somewhat less than a normal waterflow is anticipated; however, they comprise a small portion of the State.

Nevada.—The depth of snow in the mountain ranges on March 31, 1903, was very much greater than it was at the close of the corresponding month last year. There was but little or no loss of snow from melting on account of the low day and night temperatures which prevailed during February and the greater part of March. Indications are favorable for plenty of irrigation water in all districts the coming summer.

New Mexico.—At the close of March the snow had all melted in the lower valleys, but there were some patches on northern sides of the lower mountains. On the higher ranges, at the headwaters of the Canadian, Pecos, and the New Mexico streams tributary to the Rio Grande, the depth of unmelted snow ranged from 3 to 6 feet, with the deep canyons of the northern sides filled with hard packed snow, thus insuring a lasting and steady supply for the upper valleys of these streams far into the summer. On the summits of the White and Sacramento mountains the greatest depth was probably about 5 feet, with the canyons well filled; and about the same conditions obtained at the headwaters of the Gila and San Francisco rivers. Throughout the southwestern sections, at the lower altitudes, rains during the latter part of March and the 1st of April, rapidly melted the snow, in some cases causing damaging flood waters. Throughout the territory the soil was in an unusually moist condition, with the streams running bank full and a steady supply to draw on.

Utah.—The precipitation during the month was about normal. The depth of snow in the mountains of all the watersheds of the State is generally greater than usual and exceeds that for any season since the winter of 1896–97. Most of the snow fell during November, December, and January. It has therefore had plenty of time to drift and pack, and is now in splendid condition to withstand the warm weather. The temperature conditions during March were about normal, and only a moderate amount of melting occurred. The depth of snow and its drifted and well packed condition assure all sections of the State an abundant supply of irrigation water throughout the coming crop season.

Wyoming.—The March snowfall was in excess of the normal throughout most of the State, thus adding to the supply of snow which will be available for irrigation during the coming summer. The outlook for water for late summer irrigation is more favorable than it has been at this season of the year since the spring of 1899. The late snows over the eastern slope of the Big Horn Mountains has brought the supply in that section up to or above the normal, and streams of that section should carry more water the coming season than during the past three seasons. The southern half of the State has a good supply of snow in the mountains, the depths being greater than usual over almost every section and excessive in many sections. This assures a good water supply for the coming summer over the Laramie, Platte, Green, and Snake River watersheds, even though the late spring snowfall should be deficient and the early summer unusually warm.

SPECIAL CONTRIBUTIONS.

CLIMATOLOGY OF THE ISTHMUS OF PANAMA.

By General HENRY L. ABBOT.

Since it now appears probable that the Government of the United States will soon begin operations to complete a ship canal connecting the waters of the Atlantic and Pacific oceans by cutting through the Isthmus of Panama, public attention can not fail to be attracted to the region in question, where for more than twenty years two private companies have successively been engaged in prosecuting the work under serious difficulties both financial and climatic. During this long period they have collected much valuable data respecting the climate which, tropical in character and differing widely from any in the United States, deserves to be carefully studied in advance by parties proposing to take an active part in the great work. Certain portions of this information have already appeared in the MONTHLY WEATHER REVIEW, but in view of present conditions it has seemed to me desirable to prepare a summary bringing these records up to date, with an analysis designed to develop the information they convey. This is attempted in the following paper.

MONTHLY VARIATIONS IN TEMPERATURE.

In considering the climate of the Isthmus, as compared with that of more temperate regions, attention is attracted by the remarkable uniformity of temperature throughout the year. This is illustrated in Table 1, chiefly extracted from Bulletin No. 22 (serial No. 163), of the United States Weather Bureau, published in 1898.

The general elements which determine this uniformity are the direct heat received from the sun; the influence of the excessive volume of aqueous vapor held in suspension in the atmosphere; the influence of the two great seas which wash the shores of the narrow belt of land constituting the Isthmus. The influence of the seas depends on their varying absolute temperatures and on the movements of the atmosphere, as these, in a large measure, regulate the effect of the oceans in different months. The available statistics, collected chiefly by the two Panama Canal companies, throw much light upon the relative influence of these several agencies, and are sufficiently complete to warrant an attempt at a mathematical study of the problem, with a view to a thorough understanding of the climate. Each element will be considered in turn.

TABLE 1.

Localities.	Approximate latitude.	Years of observation.	Average temperature. Annual.	Hottest month.	Coldest month.	Difference.	Max. recorded.
	°		° F.	° F.	° F.	° F.	° F.
Washington	39	25	54.7	76.9	33.2	43.7	104
New Orleans	30	25	68.8	82.4	53.3	29.1	99
Key West	25	21	77.5	84.4	70.5	13.9	....
Assuan or Wadi Halfa	23	....	80.0	94.8	64.0	30.8	119
Habana	23	10	76.8	82.4	70.3	12.1	101
San Juan, P. R	18	12	78.8	81.5	75.7	5.8	101
Kingston, Jamaica	18	10	78.1	81.1	74.6	6.5	....
Barbados	13	20	75.6	76.9	73.4	3.5	....
Cayenne	4	1	79.7	82.0	77.1	4.9	....
Manila	15	17	80.0	84.0	77.0	7.0	100
Isthmus of Panama	9	26	79.7	81.0	78.3	2.7	99

Monthly mean temperatures, as determined from hourly observations, refer to the middle of each month. Hence, the relative intensity of the solar energy received during the month may be regarded as proportional to the sine of the altitude of the sun at noon, and its relative duration as proportional to the length of the time that it is above the horizon on that day. In latitude 9° north, the sun at noon is at the zenith twice during the year, once on April 13 when it is journeying northward to reach its summer solstice on June 21, and again on August 29, when returning toward its winter solstice, which it reaches on December 21. The direct heat transmitted at these altitudes is then proportional to the sines of 90°, 75° 41′, and 57° 24′, or to the numbers 1.00, 0.97, and 0.84 for the zenith, the summer solstice, and the winter solstice, respectively. It is, however, to be noted that the length of day, and hence the duration of solar radiation, attains its maximum in June and its minimum in December; and that this element therefore tends to reduce the natural fall of temperature during the northward journey of the sun, and to augment it during the approach to his southern limit. The numerical values of these several elements for each month are given in the first six columns of Table 2.

But the temperature of the air, as registered by the thermometer, is affected by the modifying influence of the aqueous vapor held in suspension, which opposes great resistance to the energy radiated from the sun by day, and still more to that radiated back from the earth both by day and by night. By day this vapor tends to largely reduce, and by night to largely increase, the temperature of the air at the earth's surface. Unfortunately a trustworthy estimate of the numerical value of this varying vaporous element is far more difficult than for solar radiation; but its influence can not be ignored in the study, although the available data can only be regarded as approximate. The actual measurements on the Isthmus consist of observations for one year, made by the old canal company at Colon in 1881, and for eight months at this place by the United States Weather Bureau from October, 1898, to May, 1899. Both series indicate as is usual in similar climates, a decided excess in the months of heavy rains; the former series gives a mean relative humidity of 0.77 for January, February, March, and April, but of 0.86 for the rest of the year; the corresponding figures of the Weather Bureau are 0.83 and 0.88. It would seem therefore that the best available estimate to adopt for relative humidity is a mean between the two series of measurements, giving 0.80 in the four dry months, 0.87 in six of the rainy months, and 0.83 in the intermediate months of December and May.

In introducing this element into the study it is needful to note that the effect of aqueous vapor in suspension upon the temperature of the air at the earth's surface is reversed every twelve hours. By day it tends to reduce the reading of the thermometer by absorbing part of the solar radiation, and to increase it by checking radiation from the earth; but as the former is much the more potent agency the aggregate influence is to reduce the reading. In other words, the resulting temperature is inversely proportional to a function of the aqueous vapor in suspension. By night the effect is wholly to increase the reading of the thermometer, by checking terrestrial radiation. In other words, the resulting temperature is then directly proportional to some function of this quantity. Although it is well known that the obstructive action in question is much less effective against solar than against terrestrial radiation, no coefficient applicable to the entire atmosphere has been established. It is, however, to be noted that in using the same numerical value for relative humidity by day and by night a corrective coefficient is virtually introduced, since by day the computation deals with the difference between the two opposing radiations and by night with only one of them. Furthermore, absolute humidity is less by night than by day.

TABLE 2.—*Influence of sun and humidity on temperature for the middle day of each month.*

Month.	Latitude, 9° north.			Relative length of—		Relative humidity.	Effective ratios by—	
	Sun rises.	Sun sets.	Altitude at noon.	Day.	Night.		Day.	Night.
	h. m.	h. m.	° ′					
January	6 22	5 58	S. 59 53	0.917	0.993	0.80	0.991	0.794
February	6 23	6 07	S. 68 01	0.927	0.983	0.80	1.075	0.786
March	6 06	6 13	S. 78 54	0.958	0.952	0.80	1.175	0.762
April	5 51	6 10	N. 89 13	9.974	0.936	0.80	1.218	0.749
May	5 41	6 12	N. 80 07	0.990	0.920	0.83	1.175	0.764
June	5 41	6 20	N. 75 41	1.000	0.909	0.87	1.114	0.791
July	5 52	6 19	N. 77 28	0.984	0.925	0.87	1.105	0.805
August	5 53	6 14	N. 84 57	0.976	0.933	0.87	1.118	0.812
September	5 52	5 57	S. 84 01	0.955	0.955	0.87	1.092	0.831
October	5 50	5 41	S. 72 28	0.937	0.973	0.87	1.026	0.846
November	5 55	5 34	S. 62 29	0.921	0.989	0.87	0.940	0.860
December	6 10	5 41	S. 57 43	0.911	1.000	0.83	0.928	0.830

Table 2 exhibits the numerical values of the elements entering into the study, and, in the last two columns, the resulting ratios indicating the relative influence upon monthly mean temperatures exerted jointly by the sun and by humidity. The values by day represent the products of the sine of the sun's altitude at noon by the relative length of day, divided by relative humidity; by night they represent the product of the relative length of night by relative humidity. If these ratios be multiplied by such numbers as will give an annual mean temperature similar to that actually observed, or by 24.5 for day and 32.7 for night, the results will be scales of monthly means representing the relative combined effect of the agencies in question in the several months. Such figures appear in Table 7.

It remains to consider the influence of the two oceans bordering the Isthmus. The old canal company made daily observations of the temperature of the water at Colon and at Naos for four years, from 1884 to 1888. The monthly means appear[1] in Table 3. The general movements of the atmosphere, which in a large measure determine the influence of oceans upon neighboring shore climates, are here governed by the locus of the ascending current of warm air which follows the sun in its travels north and south between the solstices. When the sun is north of the Isthmus southerly winds prevail, and when south, northerly winds. Observations upon the direction of the movement were made daily at Colon by the old canal company at 6 a. m., 1 p. m., and 9 p. m., during the year 1881, and the results were confirmed in a general manner by more elaborate measurements made there for eight months in 1898–99 by the United States Weather Bureau. The resulting percentage of winds blowing from the sea during each month are given in Table 3, together with the effective monthly departures from the annual mean ocean temperature, the latter being the product of the observed departures by these percentages. The final column for each ocean gives a scale of monthly mean ocean temperatures representing for each month the relative effective influence upon the shore climate, found by adding to the annual mean the effective monthly departures.

TABLE 3.—*Influence of adjacent seas on Isthmian temperature.*

Month.	Caribbean Sea.				Bay of Panama.			
	Water temperature.	Per cent of sea breeze.	Effective departure.	Active temperature.	Water temperature.	Per cent of sea breeze.	Effective departure.	Active temperature.
	°C.		°C.	°C.	°C.		°C.	°C.
January	24.5	99	—1.8	24.5	21.9	00	0.0	24.5
February	24.3	98	—2.0	24.3	19.9	00	0.0	24.5
March	25.0	95	—1.2	25.1	20.6	01	0.0	24.5
April	25.2	90	—1.0	25.3	23.3	04	0.0	24.5
May	26.0	45	—0.1	26.2	25.4	40	+0.4	24.9
June	27.0	27	+0.2	26.5	25.7	51	+0.6	25.1
July	27.4	36	+0.4	26.7	25.5	53	+0.5	25.0
August	27.6	38	+0.5	26.8	26.1	51	+0.8	25.3
September	27.7	31	+0.4	26.7	26.5	56	+1.1	25.6
October	27.4	01	+0.1	26.4	26.7	74	+1.6	26.1
November	27.2	21	+0.2	26.5	26.6	67	+1.4	25.9
December	26.6	78	+0.2	26.5	26.1	12	+0.2	24.7
Means	26.3	......	......	26.0	24.5	......	......	25.0

Before combining these several elements of the problem it is not without interest to compare them with each other when still in the form of ratios indicating for each its relative calorific influence in the different months. These ratios are shown in Table 4, and by fig. 1. For the two oceans additional ratios are added, showing their relative actual temperatures in the different months, with a view to developing the fact that, while the great equatorial current of warm water entering the Caribbean Sea largely modifies the direct action of the sun upon its temperature, the Pacific on the other side, where no such cur-

[1] At Colon the annual average was 79.3° F., the maximum, 81.9°, occurring in September and the minimum, 75.8°, in February. At Naos these figures were 76.1°, 80.0° occurring in October, and 67.8° in February.

rent exists, becomes a great natural thermometer to register the direct heat received but with a retardation of about two months, both in maximum and minimum, representing the time required to influence the temperature of so large a volume of water. This is shown to the eye on fig. 1 by comparing the two ocean temperature curves with those showing the direct solar influence. The other curves in like manner show how the two oceans combine to lower the temperature of the air on the Isthmus as the sun approaches his first zenith transit, and later to largely augment it in October, November, December, and January, when without such agency the entire region would experience a sensible fall in the thermometer.

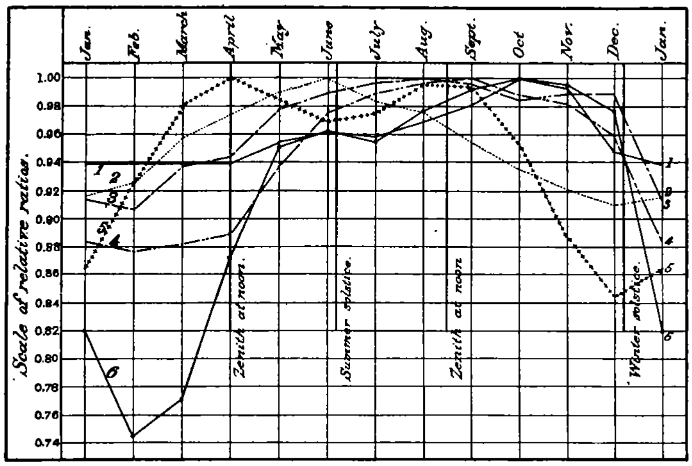

Fig. 1.—Relative influence of different factors upon the monthly temperatures on the Isthmus of Panama. (1) Influence of the Pacific Ocean (see Table 4, column 7); (2) Influence of the length of the day (see Table 4, column 3); (3) Influence of the Atlantic Ocean (see Table 4, column 5); (4) Temperature of the Caribbean Sea (see Table 4, column 4); (5) Intensity of the solar radiation (see Table 4, column 2); (6) Temperature of the Bay of Panama (see Table 4, column 6).

TABLE 4.—*Relative monthly influences.*

Month.	Solar radiation.		Caribbean Sea.		Bay of Panama.	
	Intensity.	Duration.	Actual temperature.	Effective temperature	Actual temperature.	Effective temperature.
January	0.865	0.917	0.884	0.914	0.820	0.939
February	0.927	0.927	0.877	0.907	0.745	0.939
March	0.981	0.958	0.882	0.937	0.772	0.939
April	1.000	0.974	0.889	0.944	0.873	0.939
May	0.985	0.990	0.938	0.978	0.951	0.954
June	0.969	1.000	0.975	0.989	0.963	0.962
July	0.976	0.984	0.989	0.996	0.955	0.958
August	0.996	0.976	0.996	1.000	0.977	0.969
September	0.995	0.955	1.000	0.996	0.993	0.981
October	0.953	0.937	0.989	0.985	1.000	1.000
November	0.887	0.921	0.982	0.989	0.996	0.993
December	0.845	0.911	0.960	0.989	0.977	0.947

It now remains to combine the several elements, with a view to learn how the resulting mean temperatures of the different months compare with those actually observed. This is done in Table 7; but before considering it, it is desirable to examine the actual observations made throughout the region, and to combine them in such a manner as to deduce the general monthly means affecting the Isthmus of Panama. These appear in Table 5, which briefly recapitulates the records given in full in an article on the Climatology of the Isthmus of Panama, Weather Bureau serial No. 201, with all later additions, including December, 1902. Table 6 presents a summary of the hourly observations made by the Weather Bureau at Bridgetown, Barbados, Port of Spain, Trinidad, and Willemstad, Curaçao, during the two years 1899 and 1900, added to illustrate the effect of the comparative absence of the Pacific Ocean upon climate, at about the same altitude and latitude as that of the Isthmus.

TABLE 5.—*Observed air temperatures on the Isthmus.*

Month.	Colon, 92 months.	Gamboa, 58 months	Alhajuela, 39 months.	Panama, 9 months.	La Boca, 41 months.	Naos, 70 months.	Mean.	
	°C.	°C.	°C.	°C.	°C.	°C.	°C.	°F.
January	26.25	24.10	24.96	26.17	26.20	26.60	25.71	78.28
February	26.18	23.60	26.06	26.25	26.79	26.15	25.84	78.51
March	26.47	24.15	26.55	26.62	27.25	26.33	26.23	79.21
April	26.48	24.90	27.05	27.25	27.69	27.65	26.84	80.31
May	26.73	26.85	25.55	27.07	27.01	27.90	26.85	80.33
June	26.73	27.70	26.21	26.69	27.23	28.85	27.23	81.01
July	26.77	26.75	26.02	....	26.69	28.31	26.91	80.44
August	26.23	26.60	26.20	....	26.10	28.00	26.63	79.93
September	26.57	27.15	25.97	....	26.46	27.94	26.82	80.28
October	26.18	26.55	25.46	26.45	25.84	27.45	26.32	79.38
November	26.10	26.80	25.60	26.01	25.79	26.80	26.18	79.12
December	26.47	25.75	25.76	25.78	26.48	26.80	26.17	79.11
Means	26.43	25.91	25.95	26.48	26.63	27.40	26.48	79.66

TABLE 6.—*Observed air temperatures near sea level, north shore of South America.*

Month.	Barbados.			Trinidad.			Curaçao.			Mean.	
	1899.	1900.	Mean.	1899.	1900.	Mean.	1899.	1900.	Mean.		
	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°C.
January	76.2	79.9	78.0	76.3	77.9	77.1	77.3	79.8	78.1	77.73	25.41
February	75.7	77.5	76.6	76.4	77.5	77.0	76.9	78.7	77.8	77.13	25.08
March	76.0	77.8	76.9	76.8	78.2	77.5	77.0	78.4	77.7	77.37	25.21
April	77.7	79.4	78.6	78.0	79.4	78.7	78.9	80.1	79.5	68.93	26.08
May	79.4	80.0	79.7	79.6	79.2	79.4	79.8	81.3	80.5	79.87	26.60
June	79.6	80.1	79.8	78.6	78.1	78.4	80.5	82.1	81.3	79.83	26.58
July	80.3	80.2	80.3	79.1	......	79.1	81.4	81.3	81.4	80.27	26.82
August	80.8	80.6	80.7	79.5	80.2	79.9	81.9	82.4	82.1	80.90	27.10
September	80.7	80.9	80.8	79.9	79.7	79.8	82.8	82.4	82.6	81.07	27.21
October	80.0	80.0	80.0	80.6	79.5	80.0	82.0	81.8	81.9	80.63	26.93
November	80.0	79.2	79.6	79.0	78.4	78.7	81.5	80.3	80.9	79.73	26.52
December	78.2	79.9	79.0	78.3	79.0	78.7	79.3	79.7	79.5	79.07	26.08
Means	78.7	79.6	79.2	78.3	78.7	78.7	79.9	80.6	80.3	79.39	26.30

The results of this analysis of the mean monthly temperatures of the Isthmus are presented in Table 7, of which the first four columns recapitulate the typical scales discussed above. The fifth column is derived from them by taking a mean between the mean for day and night and the two ocean scales, and subtracting 0.69 of a degree in order to reduce the annual mean to that shown by the observations. Then follows a column showing discrepancies between analysis and observation. The last three columns repeat the results, in degrees Fahrenheit, to which the coastwise average is added for convenience of comparison.

TABLE 7.

Month.	Active elements in °C.				Resultants, °C.			Temperature in °F.		
								Isthmus.		
	By day.	By night.	Caribbean Sea.	Pacific.	Computed.	Observed.	Difference.	Comp'd.	Obs'd.	South American coast.
	°	°	°	°	°	°	°	°	°	°
January	24.29	25.96	24.50	24.50	25.40	25.71	+0.31	77.72	78.28	77.73
February	26.34	25.70	24.30	24.50	25.63	25.84	+0.21	78.13	78.51	77.13
March	28.80	24.92	25.10	24.50	26.18	26.23	+0.05	79.12	79.21	77.37
April	29.84	24.49	25.30	24.50	26.35	26.84	+0.49	79.43	80.31	78.93
May	28.80	24.98	26.20	24.90	26.69	26.85	+0.16	80.04	80.33	79.87
June	27.29	25.87	26.50	25.10	26.75	27.23	+0.48	80.15	81.01	79.83
July	27.04	26.30	26.70	25.00	26.81	26.91	+0.10	80.26	80.44	80.27
August	27.38	26.54	26.80	25.03	27.04	26.63	−0.41	80.67	79.93	80.90
September	26.75	27.17	26.70	25.60	27.11	26.82	−0.29	80.80	80.28	81.07
October	25.14	27.68	26.40	26.10	26.99	26.32	−0.67	80.58	79.38	80.63
November	23.03	28.13	26.50	25.90	26.68	26.18	−0.50	80.02	79.12	79,73
December	22.74	27.15	26.50	24.70	26.07	26.17	+0.10	78.93	79.11	79.07
Means	26.45	26.23	26.00	25.00	26.48	26.48	0.31	79.66	79.66	79.39

The small discrepancies shown in this table, averaging to only 0.31 of a degree centigrade, regardless of sign, with a maximum of only half a degree, between the indications derived from an analysis of the forces in action and the results of numerous and well distributed observations would seem to warrant the belief that the former are determined with sufficient accuracy to make known their respective agencies in modifying the climate of the Isthmus. The curves on fig. 2 present to the eye the data contained in the more important columns of the table. If the direct action of the sun as modified by humidity alone be considered, there would be a range of monthly mean temperature of about 3.75° between the sun's first zenith transit in April and the middle of December; but this is reduced by the influence of humidity by night and by that of the two oceans to an observed range of 2.51° between June and January and to a computed range of 1.64° between the sun's August transit of the zenith and January. On the northern shore of South America the observations

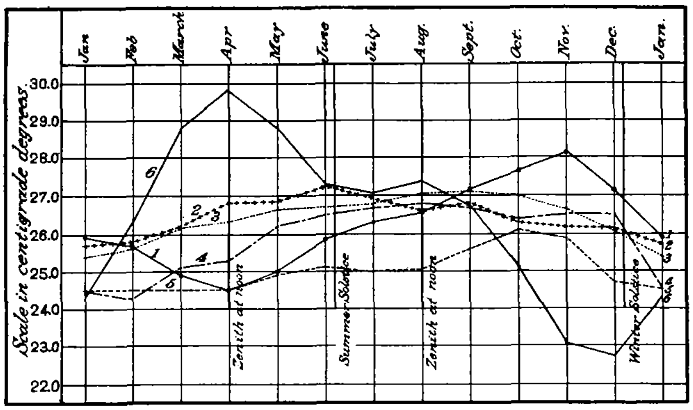

Fig. 2.—Absolute influence of different factors upon the monthly temperatures on the Isthmus of Panama. (1) Influence of the humidity of the air during the night-time (see Table 7, column 3); (2) The observed temperature (see Table 7, column 7); (3) The computed temperature (see Table 7, column 6); (4) Temperature of the Caribbean Sea (see Table 7, column 4); (5) Temperature of the Bay of Panama (see Table 7, column 5); (6) Influence of humidity and sunshine by day (see Table 7, column 2).

indicate a range of 2.13° between that transit and February, which is the coolest month, perhaps from the elimination of the influence of the Pacific. The curves indicating the influence of the two oceans show that the Atlantic is much the more important, and the close resemblance, shown by fig. 3, between the temperatures prevailing on the Isthmus and on the northern shore confirm this conclusion. The northerly winds prevailing in the first four months of the year effectually prevent the Pacific, then relatively cold, from moderating the temperature at Panama. The joint influence of varying humidity and varying length of night is a more powerful factor in effecting the nearly unvarying annual temperature of the Isthmus than perhaps has been appreciated hitherto.

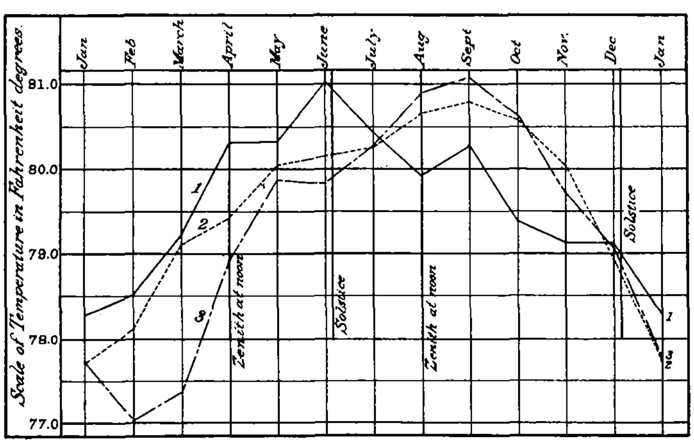

Fig. 3.—Comparison of monthly mean temperatures. (1) Isthmus of Panama, observed, 399 months (see Table 7, column 10); (2) Influence of Panama, computed, (see Table 7, column 9); northern coast of South America, 71 months (Curaçao, Trinidad, Barbados; see Table 7, column 11).

DIURNAL VARIATION IN TEMPERATURE.

The change in temperature from hour to hour is next to be considered. Observations with thermographs of the Richard type were made by the new Panama Canal company at Panama from October, 1897, to June, 1898, and at Alhajuela and La Boca nearly continuously from July, 1899, to the present date. The United States Weather Bureau made similar observations at Colon from October, 1898, to May, 1899. As all these records indicate great uniformity in diurnal variations it seems superfluous to encumber this paper with the figures in detail. A careful analysis has demonstrated that characteristic differences exist only between the Gulf coast, the interior, and the Pacific coast, and between the four dry months—January, February, March, and April—and the remaining eight months, when heavy rains prevail. Table 8 exhibits these differences in the form of general means of all the observations, to include February, 1903. As most of them were recorded in centigrade degrees, they are so given. It should be noted that, as the Weather Bureau records refer to the time of the seventy-fifth meridian, a subtraction of nineteen minutes must be made to compare them with the others, which refer to local time. This has been done on fig. 4, illustrating the table.

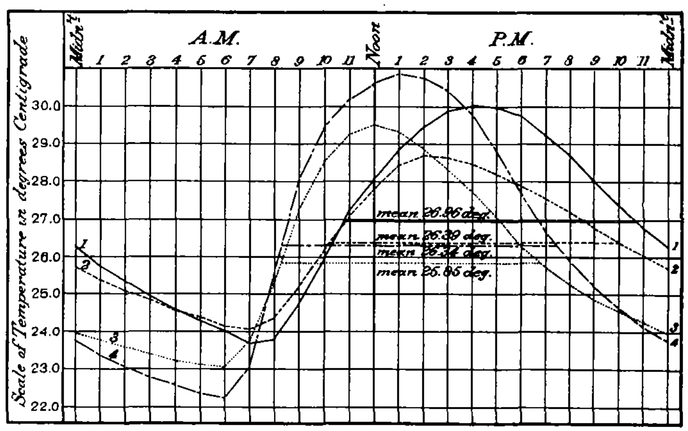

Fig. 4.—Observed diurnal variation of temperature (local time) in the dry and the wet seasons. (La Boca, dry season (see Table 8, column 5); (2) La Boca, rainy season, (see Table 8, column 9); (3) Alhajuela, rainy season (see Table 8, column 6); (4) Alhajuela, dry season (see Table 8, column 30).

Table 9 presents the results of similar observations made by the United States Weather Bureau at Bridgetown, Barbados, and Willemstad, Curaçao, added to permit of a comparison with the climate near sea level on the northern shore of South America. To reduce to local time, an addition of sixty-two minutes and twenty-four minutes, respectively, must be made, as has been done on fig. 5, which illustrates the table. The above records at Alhajuela and La Boca are repeated in the Fahrenheit scale to facilitate comparison by annual means, monthly differences in rainfall being less pronounced on the north shore than on the Isthmus.

As is the case with monthly means, the changes of temperature from hour to hour and from day to day are subject to much less variation on the Isthmus than in regions more remote from the equator; and, therefore, Tables 8 and 9 convey a more definite idea of the climate than would similar compilations for localities in the United States. It should, however, be remembered that they are based on observations made where the thermometers were not subjected to direct solar radiation; laborers exposed to the sun would experience much higher temperatures.

Figs. 4 and 5 exhibit so clearly the horary changes characterizing the climate in the interior of the Isthmus, on the Pacific coast, and on the northern shore of South America, that little need be added.

TABLE 8.—*Hourly variations in temperature in centigrade degrees.*

Hour.	Dry season, January-April. Colon, 4 months.	Dry season, January-April. Alhajuela, 12 months.	Dry season, January-April. Panama, 4 months.	Dry season, January-April. La Boca, 14 months.	Rainy season, May-December. Colon, 4 months.	Rainy season, May-December. Alhajuela, 29 months.	Rainy season, May-December. Panama, 5 months.	Rainy season, May-December. La Boca, 29 months.
1 a. m	25.28	23.37	25.18	25.76	24.65	23.82	25.80	25.38
2 a. m	25.22	23.08	24.97	25.83	24.40	23.62	25.70	25.10
3 a. m	25.08	22.80	24.75	24.94	24.20	23.43	25.56	24.83
4 a. m	25.02	22.58	24.59	24.60	24.00	23.25	25.45	24.59
5 a. m	24.82	22.37	24.45	24.30	23.88	23.13	25.37	24.39
6 a. m	24.75	22.25	24.31	24.02	23.85	23.07	25.26	24.16
7 a. m	25.00	23.04	24.27	23.71	24.20	23.78	25.29	24.07
8 a. m	25.70	25.58	24.66	23.82	25.25	25.85	25.62	24.37
9 a. m	26.82	28.05	25.85	24.75	26.58	27.29	26.20	25.21
10 a. m	27.47	29.43	27.05	26.00	27.48	28.56	26.78	26.23
11 a. m	27.98	30.20	27.88	27.23	28.05	29.28	27.24	27.11
Noon	28.22	30.64	28.32	28.08	28.40	29.54	27.40	27.82
1 p. m	28.10	30.85	28.55	28.87	28.40	29.34	27.48	28.43
2 p. m	27.85	30.75	28.82	29.50	28.32	28.90	27.56	28.70
3 p. m	27.68	30.40	29.22	29.91	27.82	28.35	27.50	28.66
4 p. m	27.42	29.81	29.28	30.05	27.52	27.78	27.40	28.48
5 p. m	26.88	28.83	28.97	30.00	26.98	27.09	27.18	28.22
6 p. m	26.35	27.71	28.45	29.77	26.25	26.29	26.96	27.92
7 p. m	26.02	26.67	27.67	29.24	25.82	25.70	26.72	27.57
8 p. m	25.98	25.90	26.95	28.71	25.70	25.27	26.52	27.22
9 p. m	25.75	25.21	26.45	28.02	25.40	24.88	26.36	26.79
10 p. m	25.70	24.65	26.02	27.41	25.20	24.56	26.22	26.41
11 p. m	25.60	24.18	25.65	26.77	25.05	24.28	26.06	26.05
Midnight	25.50	23.78	25.38	26.29	24.85	23.99	25.92	25.72
Mean	26.26	26.34	26.57	26.96	25.93	25.85	26.40	26.39
Maximum	30.60	34.50	31.60	35.20	32.20	35.90	32.10	32.90
Minimum	20.00	18.00	22.00	20.00	20.60	18.90	23.80	20.00

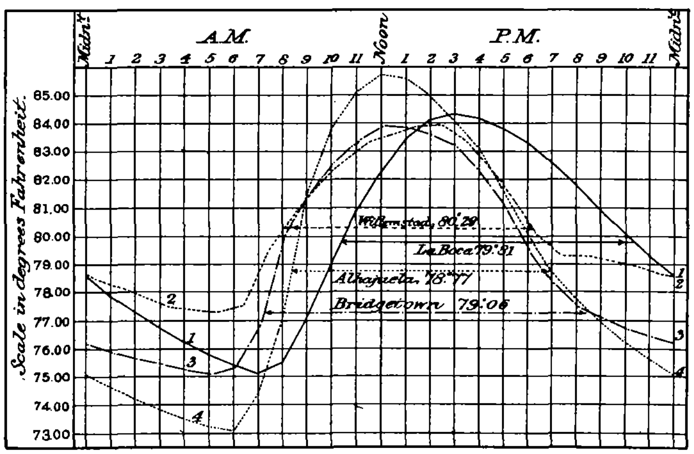

Fig. 5.—Observed diurnal variations of temperature (local time) for the whole year. (1) La Boca (see Table 9, column 5); (2) Willemstad (see Table 9, column 3); (3) Bridgetown (see Table 9, column 2); (4) Alhajuela (see Table 9, column 4).

Alhajuela is situated in the valley of the upper Chagres, among the hills which here represent the great mountain chains bordering the western coast of North and South America. Its altitude above tide is only 144 feet, and being about midway between the oceans the locality is well suited to represent the climate of the interior of the Isthmus. The temperature at sunrise in the dry season is about 72°; it soon rises rapidly, attaining about 87° at 1 p. m.; after this it falls rapidly to about 81° at sunset, and then subsides gradually to the minimum at sunrise. During the rainy season the temperature at sunrise is about 74°; it rapidly reaches a maximum at noon, about 85°, and then falls to about 80° at sunset, and later to the minimum at sunrise. Thus, during the dry season the daily temperature has a larger range and a later maximum than when rains prevail.

At La Boca, situated on the Bay of Panama, the minimum temperature occurs later, or at about an hour after sunrise, being then about 75° in both the dry and the rainy seasons. The maximum in the dry season, 86°, is reached at about 4 p. m., and in the rainy season, 84°, at about half past 2 p. m. The rate of fall is more gradual than at Alhajuela, the mercury receding at sunset in the dry season only to about 86°, and in the rainy season only to about 83°. In short, the changes on the Pacific coast are less extreme and are later than in the interior, but the daily average is about the same.

TABLE 9.—*Annual hourly variations, Isthmus and north shore, in Fahrenheit degrees.*

Hour, 75th meridian time.	Bridgetown, Barbados, 24 months, 1899–1900.	Willemstad, Curaçao, 24 months. 1899–1900.	Hour, local time.	Alhajuela, 41 months. 1898–1903.	La Boca, 43 months. 1898–1903.
1 a. m	75.66	78.06	1 a. m	74.64	77.90
2 a. m	75.43	77.80	2 a. m	74.23	77.32
3 a. m	75.28	77.62	3 a. m	73.85	76.77
4 a. m	75.19	77.52	4 a. m	73.51	76.28
5 a. m	75.37	77.44	5 a. m	73.24	75.85
6 a. m	76.98	77.63	6 a. m	73.09	75.40
7 a. m	80.10	79.44	7 a. m	74.41	75.11
8 a. m	81.60	80.84	8 a. m	77.13	75.54
9 a. m	82.70	81.84	9 a. m	81.52	77.11
10 a. m	83.41	82.62	10 a. m	83.86	79.07
11 a. m	83.93	83.28	11 a. m	85.17	80.87
Noon	83.90	83.61	Noon	85.75	82.24
1 p. m	83.65	83.95	1 p. m	85.60	83.43
2 p. m	83.15	84.00	2 p. m	84.99	84.12
3 p. m	82.21	83.51	3 p. m	84.11	84.33
4 p. m	81.12	82.68	4 p. m	83.08	84.18
5 p. m	79.44	81.33	5 p. m	81.68	83.84
6 p. m	78.27	80.09	6 p. m	80.08	83.34
7 p. m	77.58	79.48	7 p. m	78.76	82.62
8 p. m	77.16	79.29	8 p. m	77.81	81.86
9 p. m	76.81	79.05	9 p. m	76.96	80.94
10 p. m	76.55	78.92	10 p. m	76.26	80.11
11 p. m	76.25	78.65	11 p. m	75.65	79.30
Midnight	75.95	78.42	Midnight	75.09	78.62
Mean	79.06	80.29	Mean	78.77	79.84

NOTE.—Observations by the new company are recorded in local time; those of the United States Weather Bureau in thes eventy-fifth meridian time.

Unfortunately the observations at Colon, and at Panama as well, do not cover an entire year, which renders a comparison by seasons uncertain. The averages, however, show that no material difference in climate exists on any part of the Isthmus.

Fig. 5 is interesting in showing that the Alhajuela type of horary change, early minimum and maximum and rapid rate of variation, prevails at Barbados and Curaçao, and hence that the wide difference at La Boca must be attributed to the influence of the Pacific. On the contrary, the daily range at Barbados is identical with that at La Boca, while that at Curaçao is less than either, being only about 6° or 7°, as compared with 11° or 12° in the interior of the Isthmus. Nights averaging 3° or 4° cooler are a distinct advantage for the canal.

ANNUAL RAINFALL.

In connection with the study of comparative temperature on the Isthmus and on the Caribbean shore of South America, the fact that the rainfall at the latter is much less should be noted. During the period of the above observations the average annual rainfall was, at Alhajuela, 103.8 inches; at La Boca, 74.5 inches; at Barbados, 39.6 inches; at Trinidad, 56.5 inches; and at Curaçao only 16.1 inches.

Weather Bureau serial No. 201, including its appendix (or the MONTHLY WEATHER REVIEW, May, 1899), contains all rainfall records collected on the Isthmus prior to the date of its preparation in 1898, and these are therefore not repeated here. The accompanying Table 10 completes the list and includes all of March, 1903, the figures being recorded, as observed, in millimeters. Table 11 contains a summary in inches of all the observations. The number of essentially complete years at each station is indicated in brackets in the headings. In all cases the monthly means include all the observations. In computing the annual totals for years where only a month or two are missing, the gap has been supplied by the mean of all observed months of the same name at the station. Such interpolations in Table 10 are included in brackets, and for the earlier records they may easily be added in the reprint,[2] serial No. 201.

[2] Errata for Weather Bureau serial No. 201: Page 4, 7th line from bottom, for "southeast" read southwest. Page 5, 2d line from top, for "91" read 51. Page 9, 2d line from top, omit "on the coast." Page 13, 10th line from bottom, for "report" read connection. Page 15, Table 14, December 1887, for "16.28" read 12.68.

TABLE 10.—*Rainfall in millimeters, recent records.*

Month.	1898.	1899.	1900.	1901.	1902.	1903.	Means.
COLON.							
January	128	176	154	33	489	25	167
February	9	165	9	24	15	7	38
March	40	32	29	42	59	25	38
April	120	11	19	38	113	....	60
May	326	353	311	157	282	....	286
June	416	163	296	281	178	....	267
July	556	703	427	253	427	....	473
August	277	376	433	318	147	....	310
September	260	420	238	302	280	....	300
October	289	382	415	321	358	....	353
November	312	368	515	831	323	....	470
December	202	229	105	138	188	....	172
Total	2935	3378	2951	2738	2859	....	2934
GAMBOA.							
January	70	127	26	9	340	17	118
February	3	44	4	6	4	3	11
March	0	34	3	5	111	8	27
April	36	36	82	20	241	....	83
May	135	217	172	276	[277]	....	200
June	118	223	309	195	160	....	201
July	468	240	341	234	159	....	288
August	512	278	227	352	214	....	317
September	104	342	236	214	226	....	224
October	221	202	308	359	328	....	284
November	370	221	271	485	365	....	342
December	61	68	20	170	57	....	75
Total	2098	2032	1999	2325	2482	....	2170
BOHIO.							
January	314	238	179	41	567	87	238
February	32	114	12	42	23	6	38
March	77	83	26	61	24	31	50
April	269	28	73	46	131	....	109
May	371	263	188	431	[353]	....	313
June	502	376	468	306	141	....	359
July	888	451	451	500	144	....	487
August	973	330	356	616	210	....	497
September	338	226	391	611	317	....	377
October	717	491	468	535	424	....	527
November	554	265	635	869	332	....	531
December	162	157	102	296	133	....	170
Total	5197	3022	3349	4354	2799	....	3696
ALHAJUELA.							
January	....	....	46	5	[19]	5	19
February	....	....	1	1	9	[4]	4
March	....	....	1	46	10	10	17
April	....	....	104	64	144	....	104
May	....	....	259	403	[331]	....	331
June	....	....	453	305	230	....	329
July	....	297	501	202	325	....	331
August	....	259	268	454	240	....	305
September	....	205	437	404	270	....	329
October	....	301	337	566	286	....	372
November	....	274	339	546	474	....	408
December	....	48	29	124	115	....	79
Total	....	....	2775	3120	2453	....	2628
LA BOCA.							
January	....	....	19	[50]	132	14	55
February	....	....	0	[0]	1	0	1
March	....	....	0	[40]	79	1	30
April	....	....	57	[94]	132	....	94
May	....	....	285	183	251	....	240
June	....	....	226	195	138	....	186
July	....	....	402	248	136	....	262
August	....	....	152	137	106	....	132
September	....	156	....	229	172	....	186
October	....	304	....	288	271	....	288
November	....	227	....	372	290	....	296
December	....	110	....	94	72	....	92
Total	....	....	....	1930	1780	....	1862
GORGONA.							
January	87	96	67	....	....	....	83
February	5	51	3	....	....	....	20
March	0	84	5	....	....	....	30
April	35	....	80	....	....	....	58
May	128	....	180	....	....	....	154
June	111	....	317	....	....	....	214
July	470	....	501	....	....	....	486
August	505	....	281	....	....	....	393
September	[344]	....	286	....	....	....	286
October	196	....	303	....	....	....	249
November	244	....	[264]	....	....	....	244
December	100	117	[139]	....	....	....	108
Total	2225	....	2426	....	....	....	2325

TABLE 11.—*Rainfall, in inches, consolidated table to February, 1903.*

Month.	Atlantic coast.		Pacific coast.				Means.	
	Colon. [32]	Bohio. [6]	Panama. [4]	Naos. [7]	Taboga. [3]	La Boca. [4]	Atlantic. [38]	Pacific. [18]
January	3.89	9.34	0.70	0.50	0.17	1.97	6.62	0.83
February	1.44	1.50	0.73	0.08	0.00	0.03	1.47	0.21
March	1.58	2.29	1.56	0.35	0.00	1.55	1.94	0.86
April	4.32	4.94	2.84	1.71	0.81	3.72	4.63	2.27
May	12.04	13.90	7.58	4.77	6.34	9.81	12.97	7.12
June	13.50	13.31	7.86	5.49	8.16	8.23	13.40	7.44
July	16.70	18.13	7.58	4.29	6.15	10.17	17.42	7.05
August	15.13	20.50	6.81	4.78	7.12	5.39	17.82	6.03
September	12.68	16.73	7.48	7.42	7.33	7.31	14.70	7.38
October	14.15	20.44	9.49	6.64	7.32	11.12	17.30	8.64
November	20.69	20.15	11.57	6.26	4.05	10.43	20.42	8.08
December	12.14	9.25	2.75	3.21	6.56	4.78	10.70	4.33
Total	128.26	150.48	66.78	45.50	54.01	74.51	139.39	60.24

Month.	Interior stations.					
	Alhajuela. [3 years]	Gamboa. [20]	Gorgona. [3]	Bas Obispo. [10]	Culebra. [5]	Means. [41]
January	0.75	2.41	3.28	1.76	0.86	1.81
February	0.16	0.68	0.60	0.42	0.23	0.42
March	0.75	0.88	1.17	0.83	0.28	0.78
April	4.09	3.21	2.37	2.69	1.95	2.86
May	13.03	10.88	11.57	10.95	12.00	11.69
June	12.95	9.53	9.30	11.69	10.23	10.74
July	13.03	10.09	13.26	8.83	7.57	10.56
August	12.01	12.86	14.22	9.78	8.86	11.55
September	12.95	10.94	13.53	12.20	9.13	11.75
October	14.64	13.03	11.25	10.45	11.71	12.22
November	16.07	12.25	10.38	10.61	11.26	12.11
December	3.11	6.62	5.48	9.05	11.19	7.09
Total	103.54	93.38	96.41	89.26	85.27	93.58

It is evident from Table 11 that an annual rainfall of about 140 inches may be expected on the Atlantic coast, about 93 inches in the interior, and about 60 inches near the shores of the Pacific. There is a well-defined dry season beginning in December and including the months of January, February, March, and part of April, a period during which the sun is returning northward from his southern journey to the Tropic of Capricorn, and the locus of heavy rainfall has been transferred southward from the Isthmus. This comparative exemption from rain is characteristic of the interior and of the Pacific coast, but somewhat less so of the region bordering the Caribbean Sea. Clearly it is an important advantage to be able to depend upon having several consecutive dry months in which to prosecute the laying of concrete and other difficult work during the construction of the canal.

BAROMETRIC PRESSURE.

Since the date of Weather Bureau serial No. 201, reprinted from the MONTHLY WEATHER REVIEW for May, 1899, continuous observations with a Richard barograph have been made at Alhajuela by the new Panama Canal company from July, 1899, to date, except in May, 1902; and the Weather Bureau made a similar series at Colon from October, 1898, to May, 1899. The heights of the instruments above tide were at Alhajuela, 144 feet, and at Colon, 25 feet. These records accord with the earlier data in demonstrating the great uniformity of pressure throughout the Isthmus. The extreme range at Alhajuela during nearly four years has been only 0.44 inch, the maximum reading, 30.11 inches, being noted in February, 1900, and the minimum, 29.67 inches, in November, 1902, both reduced to sea level and corrected for instrumental error; the corresponding mean reading is 29.904 inches. If this uniformity had been understood, much use of the barometer might have been made to determine heights in the preliminary reconnaissances, which the dense undergrowth rendered exceptionally difficult.

The horary variations in barometric pressure are best studied in the form of departures from the mean reading, which enable a direct comparison to be made between the curves in the dry and the rainy seasons. This is done in Table 12, and is shown to the eye on fig. 6. The figures cover the entire record at Alhajuela from July, 1899, to December, 1902, inclusive. It will be noted that the same characteristic differences between the temperature curves in the two seasons, shown in Table 8 and fig. 4, reappear in barometric pressure. The barometric readings in this table are given as recorded, without correction.

TABLE 12.—*Horary barometric pressure, in millimeters.*

Hours.	Dry season.		Rainy season.		Hours.	Dry season.		Rainy season.	
	Means.	Departures.	Means.	Departures.		Means.	Departures.	Means.	Departures.
1 a. m.	760.48	—0.49	760.20	—0.48	2 p. m.	758.59	+1.40	758.41	+1.31
2 a. m.	760.26	—0.27	759.94	—0.22	3 p. m.	758.27	+1.72	758.23	+1.49
3 a. m.	760.10	—0.11	759.79	—0.07	4 p. m.	758.23	+1.76	758.29	+1.43
4 a. m.	760.10	—0.11	759.82	—0.10	5 p. m.	758.43	+1.54	758.51	+1.21
5 a. m.	760.28	—0.29	759.99	—0.27	6 p. m.	758.90	+1.09	758.94	+0.78
6 a. m.	760.62	—0.63	760.28	—0.56	7 p. m.	759.43	+0.56	759.42	+0.30
7 a. m.	760.94	—0.95	760.59	—0.87	8 p. m.	759.93	+0.06	759.88	—0.16
8 a. m.	761.11	—1.12	760.74	—1.02	9 p. m.	760.36	—0.37	760.26	—0.54
9 a. m.	761.03	—1.04	760.64	—0.92	10 p. m.	760.65	—0.66	760.49	—0.77
10 a. m.	760.64	—0.65	760.24	—0.52	11 p. m.	760.78	—0.79	760.55	—0.83
11 a. m.	760.18	—0.19	759.78	—0.06	Midnight	760.71	—0.72	760.42	—0.70
Noon	759.68	+0.81	759.24	+0.48					
1 p. m.	759.15	+0.84	758.79	+0.93	Mean	759.99	0.00	759.72	0.00

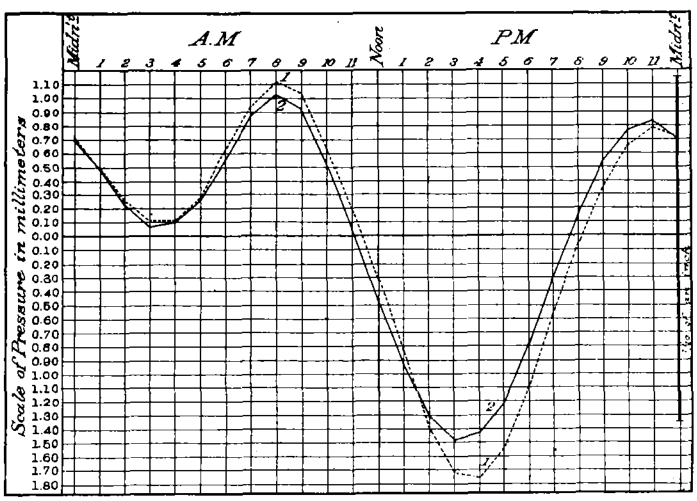

Fig. 6.—Diurnal curve of barometric pressure at Alhajuela. Dotted line, mean of the four dry months for three years; mean pressure, 759.99 (see Table 12, column 3). Full line, mean of eight rainy months for four years; mean pressure, 759.72 (see Table 12, column 5).

WINDS OF THE ISTHMUS.

During seven months, from October, 1898, to May, 1899, the United States Weather Bureau made continuous observations upon the velocity of the wind at Colon, using a Robinson anemometer, the height of the instrument being 47 feet above ground. Directions were also noted at 8 a. m. and 8 p. m., and the results accord well with those noted by the old canal company in 1882, and reported in Weather Bureau serial No. 201, reprinted from the MONTHLY WEATHER REVIEW for May, 1899.

These velocity observations are specially valuable, as they constitute the only direct measurements ever reported on the Isthmus. They show during the whole period a great uniformity from day to day and from month to month, the wind increasing gently from about six miles per hour at midnight to about eight and a half miles at two or three o'clock in the afternoon, and then subsiding gradually. The strongest winds came from the Caribbean Sea, usually attaining a velocity of about 20 miles per hour, and on one occasion a velocity of 24 miles.

TABLE 13.—*Summary of wind at Colon.*

Month.	Total.	Mean velocity.	Strongest wind.	Estimated direction.
	Miles.	*Miles.*	*Miles.*	°
October, 1898	4123	5.5	20 w.	s. 25 e.
November, 1898	3907	5.4	20 nw.	s. 55 e.
December, 1898	5276	7.1	20 ne.	n. 39 e.
January, 1899	4946	6.6	16 ne.	n. 33 e.
February, 1899	4931	7.3	24 nw.	n. 19 e.
March, 1899	5765	7.7	20 ne.	n. 34 e.
May, 1899 *	3386	7.1	20 nw.	n. 26 e.

* Eleven days missing.

HEALTH ON THE ISTHMUS.

The health statistics during the construction of the Panama Railroad have never been made public, but are well known to have been appalling. At that date it was not understood that natives of the temperate regions can not safely perform arduous manual labor under exposure to a tropical sun, and that dependence for such work must be placed upon the negroes of the West Indies. White men can supervise, but must not attempt more. Fortunately the health records during the canal operations, and especially those during the operations of the new company, which should furnish the best guide in view of the great changes in the physical condition of the region, have been preserved, and are shown in Table 14, contributed by Dr. Lacroisade, for many years the medical director of the fine company hospital near Panama. He is thoroughly familiar with the Isthmian conditions, and the notes following the table are a translation from a letter written by him on March 9, 1902, and published in The Medical News, vol. 80, p. 707, New York, 1902. His views on this important subject are entitled to the highest confidence. He attributes the marked improvement, shown in Table 14, to the better accommodations of the laborers, to better drainage, and especially to the fact that the excavations have reached a level below the poisonous emanations of decaying organic matter. The period of serious sickness, always to be expected in tropical regions, has apparently already been passed at Panama. It is interesting to note that whereas the percentages of disease and of mortality for general ailments have remained sensibly unchanged during three suc-

TABLE 14.—*Official health statistics of the Panama Canal.*

Years.	Effective force employed.	Percentage of disease.			Percentage of mortality.		
		Diseases of Europe.	Diseases due to climate.	Total.	Diseases of Europe.	Diseases of climate.	Total.
Old company:							
1881	928	21.02	42.03	63.04	1.94	4.74	6.68
1882	1,910	18.85	47.64	66.49	3.21	4.39	6.60
1883	6,267	23.24	42.62	65.86	3.20	4.46	6.66
1884	17,615	27.58	36.95	64.57	2.58	4.08	6.66
1885	15,215	11.93	49.14	61.07	1.73	3.79	5.52
1886	14,935	14.01	43.88	57.89	1.67	3.43	5.10
1887	16,217	21.83	39.25	61.07	3.22	3.99	6.21
1888	13,725	12.17	40.46	52.63	1.81	2.54	4.35
Mean	10,854	18.83	42.75	62.58	3.05	3.92	5.97
Receiver:							
1889	1,826	......	......	......	......	......	......
1890	about 800	......	......	......	......	......	......
1891		......	......	......	......	......	......
1892		......	......	......	......	......	......
1893		......	......	......	......	......	......
1894		......	......	......	......	......	......
Mean	971	......	......	49.68	......	......	2.88
New company:							
1895	1,225	......	......	49.95	2.05	0.89	2.94
1896	3,715	......	......	39.91	2.08	0.84	2.92
1897	3,980	......	......	51.85	1.99	1.00	2.99
1898	3,400	28.26	13.65	41.91	1.76	0.27	2.03
1899	2.500	19.76	5.84	25.60	2.24	0.12	2.36
1900	2,000	17.05	8.50	25.55	3.00	0.25	3.25
1901	2,000	18.60	6.85	25.45	1.55	0.20	1.75
Mean	2,703	20.92	8.71	37.17	2.10	0.51	2.61

cessive epochs, they have fallen enormously in the later years for diseases incident to the local climate.

1898.—Among the employees of the company there was no sickness of an epidemic character; the sanitary conditions were satisfactory.

On the Isthmus generally, a light epidemic of influenza prevailed during the months of January and February, but no yellow fever or other sickness of an epidemic form appeared.

1899.—Among the employees of the company there was a single case of yellow fever, contracted at La Boca, in November by a Frenchman recently arrived and employed on the harbor works. He recovered. There was no other sickness of an epidemic form among the employees of the company, and the sanitary condition was satisfactory.

In the City of Panama, between May and the middle of December, there were about 139 cases of yellow fever. Its victims were chiefly foreign sailors arriving in the bay and Colombian soldiers from the interior.

In June and July a rather severe epidemic of influenza occurred. In September a short epidemic of measles caused some deaths. The City of Colon appeared to be proof against yellow fever.

1900.—Among the employees of the company a single case of yellow fever occurred, terminating in recovery, and there was no other sickness of an epidemic form. The sanitary condition was satisfactory, notwithstanding the rather high death rate caused by a larger number than usual of deaths from chronic diseases of a general type.

On the Isthmus, generally, yellow fever, which had disappeared after the middle of December, returned in March. Between that date and September 10, about 138 cases occurred in Panama, of which 128 were among the Colombian soldiers from the interior. There was no other sickness of an epidemic form. The City of Colon escaped yellow fever.

1901.—No epidemic appeared among the employees of the company, and the sanitary condition was very satisfactory.

On the Isthmus, generally, yellow fever, of which no case had been reported since September 10, 1900, was again imported in January, 1901, by a priest and a sister of charity coming from Buenaventura. It was communicated to a sister of the orphan asylum of the central hospital and then to the superior. The latter alone recovered. These four were the only cases in January, 1901; and since then up to the present month (March, 1902) there has been no return of the disease.

In April, 1901, a serious epidemic of smallpox appeared in Panama and still continues. The employees of the company have suffered very little, a result which should be attributed to the numerous vaccinations which have been made.

The City of Colon appears always to escape these epidemics.

General conclusions.—Considering the average figures for the last four years, I find that with a personnel of 2275 the percentage of disease has been 29.65, and the mortality 2.35 per cent. These figures do not exceed those on large works in any country.

It should, however, be added that this personnel has been long on the Isthmus and is well acclimated; I may even say extremely so, since 91 per cent of the total death rate is due to chronic organic diseases common to all countries, leaving only 9 per cent of it chargeable to the diseases of the local climate.

The classified employees, which constitute about 8 per cent of the entire force, are represented in the total death rate by 5.70 per cent, while the laborers are represented by 94.30 per cent. The mortality in the latter class is therefore the greater.

Among infectious diseases on the Isthmus yellow fever is undoubtedly the most to be feared by unacclimated persons of the white race. During the two recent epidemics of yellow fever—the first from May to December 15, 1899, and the second from March to September 10, 1900—only two cases appeared among the personnel of the company. Both were French, one a workman on the wharf at La Boca who had been only a few days in the country, and the other the head nurse of the company's hospital who had held this position for two years. To these should be added the superior of the sisters at the hospital, attacked in January, 1901, after three or four months of residence, one of the four solitary cases of this month just mentioned. These three cases recovered. I attribute the last two cases to infection proceeding from the foreign hospital, which received a large number of the 261 cases occurring in the different epidemics and which, by its too close proximity, is a menace to the hospital of the company. The latter offers satisfactory sanitary conditions.

I have mentioned in former reports the disappearance of yellow fever from the Isthmus from the year 1892 to the year 1897. This would lead to the belief that the disease is in no wise necessarily endemic. In 1897, indeed, between the beginning of March and the beginning of August there were about 70 cases, as well at Panama as on a portion of the line of the canal, but no case occurred at Colon.

I will remark that the City of Colon, which up to about the years 1891–92, was a terrain than which nothing could be better for yellow fever—reputed more dangerous than the City of Panama—has since that time remained free from any infectious disease and has escaped the yellow fever epidemics of 1897, 1899, and 1900. This is evidently due to the sanitary works which have been executed, the filling up of the many little swamps and the cleaning of streets which before were veritable sewers. By these improvements the City of Colon has been considerably freed from the swarms of mosquitoes which rendered life insupportable.

Might not a like result be secured for the City of Panama (1) by a good supply of pure water, (2) by drains to conduct sewerage to the sea, to which its situation and conformation are easily adapted, and (3) by watering the streets daily in the dry season, and by cleaning them daily throughout the entire year. Now they are in a repulsive condition of filth. These three improvements, which I consider fundamental and essential, are now wholly neglected.

There should also be instituted an effective quarantine service for vessels arriving in the harbor, for beyond all doubt the epidemics of 1897, 1899, and 1900, and the few cases which occurred in January, 1901, were due to importations, in one instance from the Atlantic and in three instances from the Pacific.

I do not expect by these measures to remove completely from Panama its character as a terrain favorable for the propagation of yellow fever; but certainly, if thoroughly applied, they would exclude some epidemics and render a residence on the Isthmus less dangerous for unacclimated persons of the white race.

The important works executed from one end to the other of the line of the canal have also done much to improve the sanitary conditions existing on the Isthmus.

MEAN BAROMETRIC PRESSURE AT SEA LEVEL ON THE AMERICAN ISTHMUS.

By GENERAL HENRY L. ABBOT, dated Cambridge, January 27, 1903.

The series of meteorological observations made on the Isthmus by the new Panama Canal company now includes a continuous hourly record of barometric pressure at Alhajuela on the upper Chagres River since June, 1899, lacking only a single month, May, 1902. Unfortunately, an undetermined error in the reading of the barograph prevents this series from being available in connection with the numerous observations made by the Weather Bureau in the West Indies, and published in the MONTHLY WEATHER REVIEW; and it has, therefore, seemed to me to be desirable to determine it with all possible precision. As there are no facilities for a direct comparison with a standard barometer, resort must be had to indirect methods. The height of the instrument above mean tide (148 feet) is accurately known, together with the simultaneous hourly temperatures at the station. If then, the true reading of the barometer at mean sea level in this vicinity can be determined, the difference between this quantity and the mean of the recorded readings of the instrument reduced to sea level should furnish the desired instrumental correction.

The MONTHLY WEATHER REVIEW supplies all needed facilities for determining the true barometric reading at mean sea level in this region. It has furnished in full for the years 1899 and 1900 the hourly barometric pressure and corresponding air temperatures at various stations in the West Indies, of which the heights above sea level are recorded. Since hourly observations eliminate horary variations in pressure, and full annual series eliminate monthly variations, observations so long continued in a region of extraordinary uniformity of pressure can certainly be trusted to essentially eliminate abnormal variations, together with any small instrumental errors of instruments so carefully adjusted as those of the Weather Bureau. The probable error of a reading at mean sea level, thus deduced, should be insignificant. It remains to select the stations.

To eliminate gravity variations, the stations should lie as nearly as possible on the same parallel of latitude as Alhajuela. Four fulfill this condition, and all of them, fortunately, are but little elevated above the sea, thus favoring the needed reductions. Two of these stations are Willemstad, Curaçao, and Bridgetown, Barbados, at each of which two full years are available. At Port of Spain, intermediate between the two, the records cover ten months in 1899 and nine months in 1900. To utilize the nineteen available months, it is only needful to correct the error due to the missing months by interpolations, which may be found by adding to the partial annual means the difference between the mean for the corresponding months in the four complete years and their true annual means, and then adding to this for each missing month its departure on the 4-year curve. The fourth station is Colon, where, unfortu-